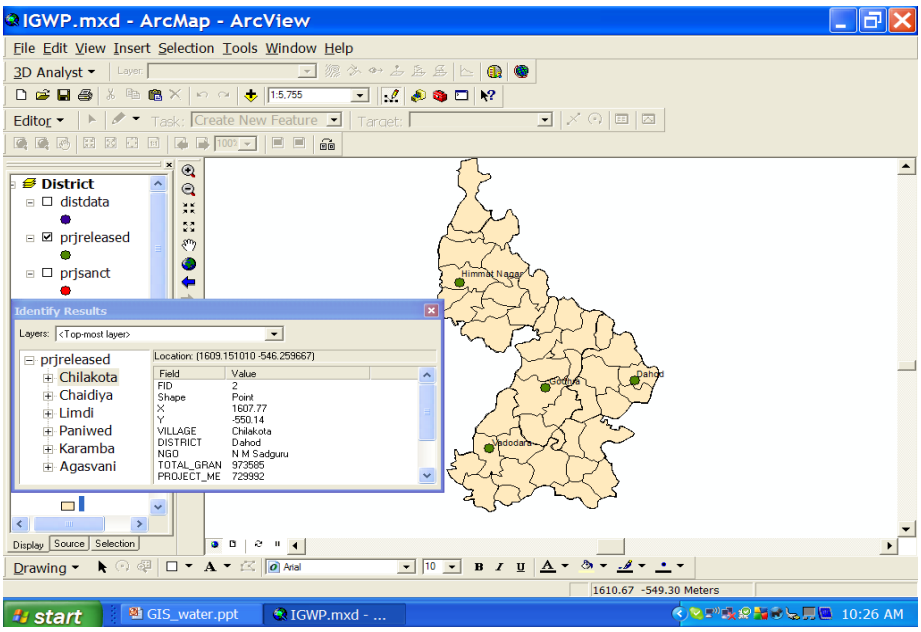
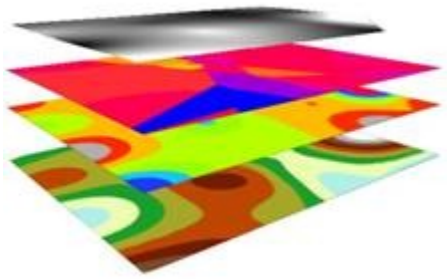
Basics of GIS

GIS is abbreviation of Geographic Information system. Aside from much hype about it, GIS in a very simple term is just a combination of Maps and database. It is nothing but a ***spatial database*** .



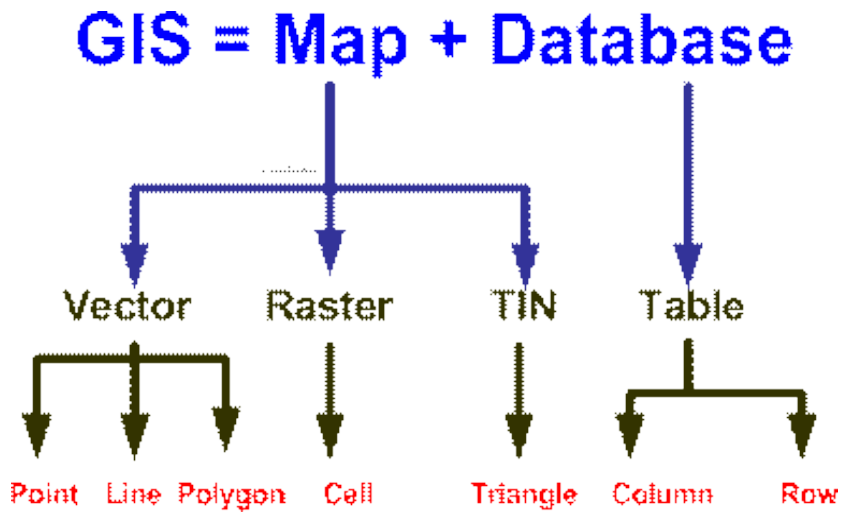
GIS is a combination of Maps and Database. Depending on how we represent the map, every element in the map may have an association or connection with some database table. For example, selecting an area map that has an association with a table will show all the attributes data related to that selection.

Maps in GIS can be separated into several layers. Each layer map can be viewed in combination with some other layers, or it can be seen as a separate layer. You may extract some information based on these layers. For instance, you may search for some location based on several criteria, or find some pattern over several years map, query features that near to some other feature, and so on. Later in this series of GIS tutorial, you may learn further query, analysis, and modeling and enhance decision support system using the power of GIS.



Database is represented by tables. Table consist of rows represent the data and columns characterize the attributes of the data. On the other hand, Map may be represented by several GIS data model such as vector, image (raster) and triangles. Knowing the data model of GIS is important because it gives you

idea on how the computer stores the data and how the data is analyzed. Depending on this GIS data model and representation, the way to perform your analysis and the result you obtain may be different. In this section, you will learn this GIS data model.

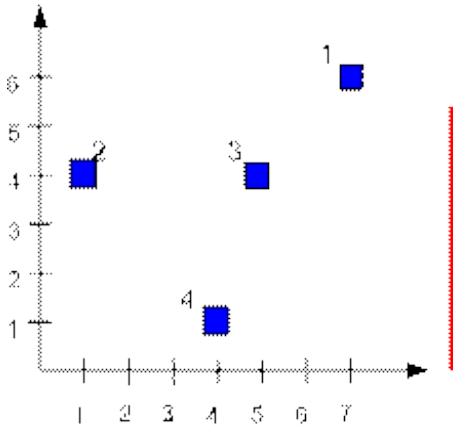


GIS Vector Data

The most common representation of a map is using vector data, that is consist of points, line and polygons.

Point

Each point is stored by its location (X, Y) together with the table attribute of this point.
For example, 4 points below has their coordinate location in (X, Y) and each point has attributes of deep and amount of water contamination.

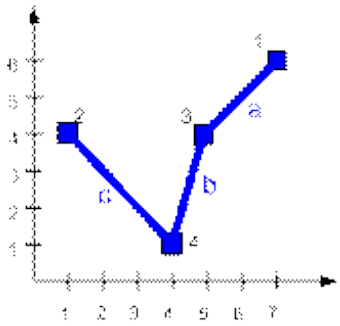


Point No	X	Y
1	7	6
2	1	4
3	5	4
4	4	1

Point No	deep	amount
1	12.35	63.45
2	25.79	79.83
3	3.50	24.34
4	17.52	69.23

Line

Each line is stored by the sequence of first and last point together with the associated table attribute of this line. For example, three lines below (a, b and c) have their first and last node to distinguish their location and each line has attributes of flow and capacity of the sewerage pipe. Notice that each node has coordinate (X, Y) that is stored in another table.



Node No	X	Y
1	7	6
2	1	4
3	5	4
4	4	1

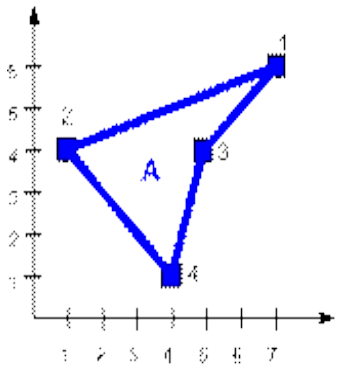
Line	First Node	Last Node
a	1	3
b	3	4
c	4	2

Line	Flow	Capacity
a	960	2200
b	1250	2000
c	1100	2000

Because the first and end node coordinates of each line is known, the length of a line or poly-line (sequence of lines) can be easily computed.

Polygon

Polygon is represented by a *closed* sequence of lines. Unlike line or poly-line (sequence of line), polygon always closed. That is, the first point is equal to the last point. A polygon can be represented by a sequence of nodes where the last node is equal to the first node. For example, polygon A below has its first and last node in node number 1 to settle its location. Aside from location attributes, the polygon has associated attributes of area and bacterial population. Notice that each node has coordinate (X, Y) that is stored in another table.



Node No	X	Y
1	7	6
2	1	4
3	5	4
4	4	1

Polygon	Node sequence
A	1,3,4,2,1

Polygon	Area	Population
A	15.23	12.35

Using polygon, several geometric attributes such as area and perimeters can be derived easily.

What things do we represent as Point, Line or Polygon?

Data representation is depending on

1. Map scale, and
2. Functions you want to perform in your later analysis.

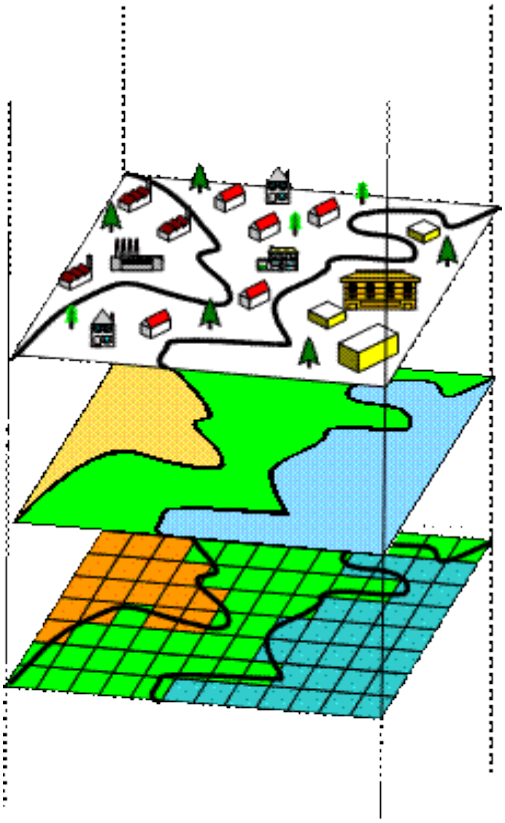
What things represented as *line* (or poly-line) may be easy to guess: road, pipeline, water line, rivers, bus route and so on that have basic shape similar to line or combination of lines.

What things we represent as a point or polygon? In the city map scale around 1:25,000 or 1:10,000; you may represent buildings, post offices, bus stops, hospitals, police stations, wells, and

so on as points. If you need more detail map, however, say in the scale of 1:1000, those infrastructure listed above may be better to be represented as polygons, rather than point.

Point is simpler to input and analyzed. Polygon need more points to input but you may get the area, perimeter and other geometric attributes computed by the GIS software rather than you input manually. If you are sure that you do not need these geometrical attributes in your later analysis, input your data as point rather than polygon.

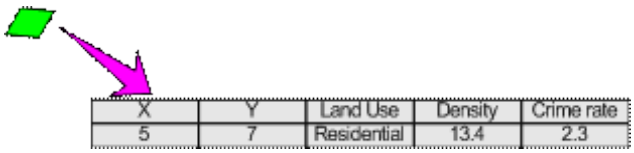
One method to represent GIS data model is using raster or Image.



The figure on the left shows a land use map of a neighborhood. In the top layer, we use symbols to represent the location of houses or factories or commercial centers. The black lines are

the land use boundary. The middle layer shows the land use map and the bottom layer is the conversion from the land use map into raster model.

Raster model use grid or cell as unit to store data, similar to Image. Each cell has coordinate and corresponding attributes. For example, cell in the location (5, 7) may have associated attribute of land use, population density and crime rate.

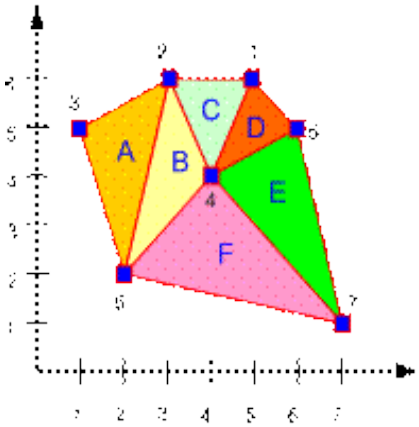


X	Y	Land Use	Density	Crime rate
5	7	Residential	13.4	2.3

Using raster model to store GIS data, we can use many image processing analysis that have been quite developed in the fields of computer science and computer vision, which is outside the field of geography and spatial analysis.

TIN GIS Model

TIN or Triangulated Irregular Network stored GIS data for 3D surface model. The basic unit is a triangle. Because a triangle consists of three lines connecting three nodes, each triangle will have three neighbors (except those on the side or periphery). The triangle is represented by a sequence of three nodes. Each triangle may have other associated attributes such as population density, crime rate, etc. in another table.



Node No	X	Y	Z
1	5	6	3
2	3	6	5
3	1	5	6
4	4	4	4
5	6	5	3
6	2	2	2
7	7	1	8

Triangle	Node Sequence	Neighbors
A	3,2,6	-,B,-
B	2,4,6	A,C,F
C	2,1,4	-,D,B
D	1,5,4	C,-,E
E	5,7,4	D,-,F
F	4,7,6	B,E,-

Map Scale

If you never learn about scale map here is the simple explanation. Map is a projection of the earth into a flat two dimensional plane.

$$\text{Scale of map} = \frac{\text{distance on the map}}{\text{distance on the ground}}$$

When we say scale 1:1 the meaning is 1 centimeter in the real ground is corresponding to 1 centimeter on the map, 1 inch on the map is equal to 1 inch on the map. The unit is not important. Map scale is using relative unit that you can use any distance unit (inch, cm, m, yard, km, mile, nautical mile etc.) to get the same scale.

Scale 1:100,000 have meaning that 1 cm on the map is equivalent to 1 km on the ground. Using this scale, if the diameter of your city is about 20 km, you may print the city map on a piece of A4 paper (29.7 cm by 21 cm).

Architects, mechanical engineers and civil engineers usually use 1:10 or 1:20 for detail construction drawing and 1:100 or 1:500 for site plan. To see your neighborhood in quite detail, you may use scale 1:500 to 1:1000. To see your whole city in a piece of A4 paper, you may use scale about 1:10,000 to 1:100,000 (depending how large is your city area).